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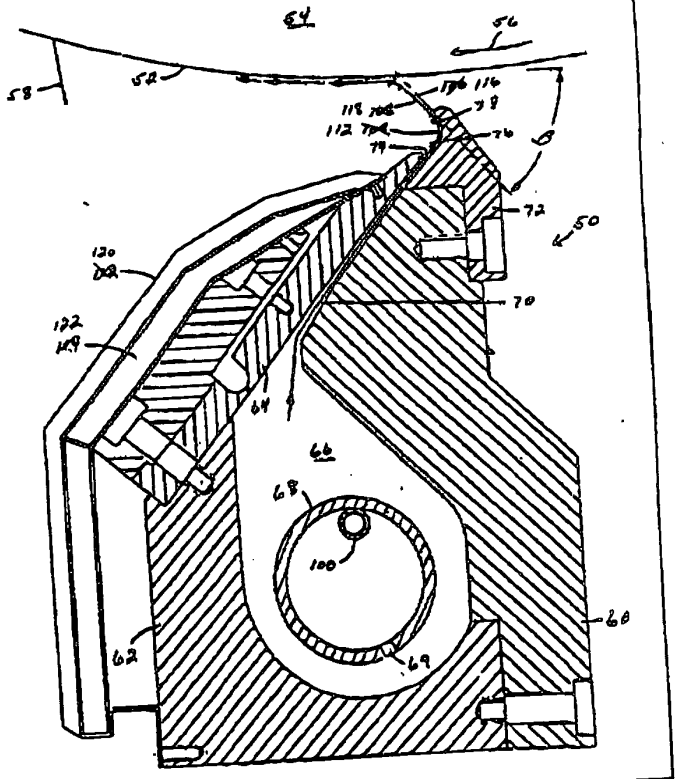
(54) Title: METHOD OF MINIMIZING SKIP COATING ON A PAPER WEB

(57) Abstract

A fountain applicator for applying coating liquid onto a web of paper carried past the applicator, has a coating liquid flow path that includes a curved surface along which a sheet of the coating liquid is flowed to subject the sheet to centrifugal force to cause air entrained in the coating liquid to move toward one side of the sheet away from the curved surface. After being flowed along the curved surface, the sheet of coating liquid is directed toward the web in a free standing jet curtain of coating liquid, to contact an opposite relatively air-free side of the coating liquid sheet against the web surface while the one side of the sheet is out of substantial contact with the web surface. Contacting the web with coating liquid that is relatively free of entrained air minimizes the occurrence of skip coating on the web, especially when the web is travelling past the applicator at high speeds.



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METHOD OF MINIMIZING SKIP COATING ON A PAPER WEB

Background of the Invention

The present invention relates to a method of and apparatus for applying liquid coating material onto a moving web of paper, and in particular to a coating method and apparatus of the fountain applicator type.

Coating a web of paper is generally effected by the application of a liquid coating material onto a moving web. The coating material may be comprised of a solid constituent suspended in a liquid carrier. The quality of the coating applied onto the paper web depends upon a number of factors, and important one of which being how the material is applied. The application of the coating material should preferably result in a coating that is continuous and uniform across the web.

One method previously used to coat paper webs was to feed liquid coating material to applicator rolls that applied the material directly onto the moving web. While the use of applicator rolls yields a fairly uniform coating across the web, as web speeds increase, there often occurs a film split pattern in the coating applied onto the web, i.e. cross-direction variations in the weight of the coating on the web. This technique therefore does not lend itself to coating webs at high speeds. Direct application by rolls also creates forces in the roll/web nip that imbed or force coating material into the web instead of covering the outer surface of the web to enhance smoothness.

In an attempt to avoid these and other problems, the art developed a coating process in which the liquid coating material was jetted in a free standing curtain of coating liquid directly onto the moving web with a fountain

applicator. While fountain applicators overcome many of the limitations of roll applicators, in their use, skip coating often occurs. Skip coating is caused by air in the coating liquid being contacted against the paper web and preventing the coating liquid from uniformly contacting and being uniformly applied onto the web surface. To decrease the severity of the skip coating problem, fountain applicators customarily include coating/air separation equipment to remove air from coating liquid prior to delivery of the coating liquid to the applicator, but the equipment is not 100 % effective and some air remains entrained in the coating liquid jetted against the web surface and causes skip coating.

Objects of the Invention

An object of the present invention is to provide an improved fountain applicator for applying liquid coating material onto a paper web, in which the resulting coating on the web is substantially skip free.

Another object is to provide such a fountain applicator, in which a sheet of coating liquid is flowed along a curved surface substantially immediately prior to being impinged against the web, to subject the sheet to centrifugal force to cause air entrained in the coating liquid to move toward one side of the sheet away from the curved surface.

A further object is to provide such a fountain applicator, in which the sheet of coating liquid, after leaving the curved surface, is directed toward the web in a free standing jet curtain of coating liquid that is impinged against the web, such that the side of the jet curtain of coating liquid that corresponds to the opposite side of the sheet that is relatively free of entrained air contacts the web surface while the other side of the jet curtain of

coating liquid is out of substantial contact with the web surface.

Summary of the Invention

In accordance with the present invention, an apparatus for applying a coating liquid onto a surface of a moving web comprises an elongate concave curved surface that is positionable proximate to, transversely of and spaced from the web; and means for forming an elongate sheet of coating liquid, for flowing the sheet along the curved surface, and for then projecting the sheet in a free standing jet curtain of coating liquid that is directed toward, against and across the surface of the web. The coating liquid sheet, upon being flowed along the curved surface, is subjected to centrifugal force to cause air entrained in the coating liquid sheet to move to one side of the sheet that is away from the curved surface. The free standing jet curtain of coating liquid is directed against the web such that a side of the jet curtain of coating liquid, which corresponds to an opposite relatively air-free side of the coating liquid sheet, contacts the web surface, while the other side of the jet curtain of coating liquid is out of substantial contact with the web surface. Thus, only coating liquid that is relatively free of entrained air contacts the web surface to provide on the web surface a coating that is substantially skip free.

The invention also contemplates a method of applying a coating liquid onto a surface of a moving web, which comprises the step of flowing a sheet of coating liquid along an elongate concave curved surface that is proximate to, extends transversely of and is spaced from the web, to subject the coating liquid sheet to centrifugal force to cause air entrained in the coating liquid to move to one side of the sheet that is away from the curved surface. Also included is the step of directing the sheet of coating

liquid, after it has been flowed along the curved surface, in a free standing jet curtain of coating liquid toward, against and across the surface of the web to contact the web surface with a side of the jet curtain of coating liquid that corresponds to an opposite relatively air-free side of the coating liquid sheet, while maintaining the other side of the jet curtain of coating liquid out of substantial contact with the web surface, whereby only coating liquid that is relatively free of entrained air cohtacts the web surface.

Brief Description of the Drawings

Fig. 1 shows a prior art fountain applicator;
Fig. 2 shows a fountain applicator that embodies the teachings of the present invention;
Fig. 3 illustrates a coating supply system of a type that may be used to deliver coating liquid to the fountain applicator of the invention;
Fig. 4 shows an alternate embodiment of a fountain applicator that incorporates the teachings of the invention; and
Figs. 5A and 5B are graphs that respectively show the degrees gloss and the Parker Printsurf smoothness of a coating applied onto a web with the fountain applicator of Fig. 2, for various speeds of travel of the web past the applicator.

Detailed Description

The Prior Art

A fountain applicator of a type contemplated by the prior art is shown in Fig. 1 and indicated generally at 20. The applicator is part of a paper coating machine, and extends parallel to and coextensively with a movable support or backing roll 22 which rotates in a direction shown by an

arrow 24 and supports a web of paper 26 during its travel past the applicator. The applicator has front and rear walls 28 and 30 that form an elongate metering slot 31 leading to an elongate outlet nozzle 32. The metering slot communicates with a chamber 34 that receives liquid coating material under pressure from a source of material, for flow of the coating liquid upwardly to and through the outlet nozzle, as indicated by the line and arrow. The outlet nozzle extends coextensively with the backing roll 22 and transversely of and across the paper web, and is proximate to and faces the paper web where it is supported on the backing roll. The upper end of the applicator rear wall 30 extends beyond the upper end of the applicator front wall 28 and defines a gap 36 with the web, and where it extends beyond the applicator front wall, the applicator rear wall has a flat surface 38. Coating liquid introduced into the chamber 34 flows upwardly to and out of the outlet nozzle in a sheet of coating liquid 40 that flows across the flat surface 38 at the upper end of the applicator rear wall. Upon leaving the flat surface, the sheet of coating liquid is directed in a free standing jet curtain of coating liquid against and transversely across the paper web, at an acute included angle α within the web, as the web is moved past the applicator.

In operation of the applicator 20, the free standing jet curtain of coating liquid is impinged against the surface of the backing roll supported paper web 26 to apply onto the web surface an excess layer of coating liquid that is doctored to a desired coat weight by a downstream doctor 42. In order for the applicator to apply an excess coating layer that is reasonably free of voids or skips, it is imperative that there not be an excessive amount of air entrained in the coating. To minimize entrained air, a conventional air removal system may be incorporated into the coating supply system that delivers coating liquid to the applicator, such air removal systems being well known

in the art and two representative examples of such being taught by U.S. patents Nos. 4,290,791 and 4,643,746. However, even when an air removal system is employed, some air remains entrained in the coating and contacts the web, causing skip coating on the web, especially at high speeds of travel of the web past the applicator.

The Invention

In improving upon prior fountain applicators, the invention provides an improved fountain applicator that is uniquely configured to apply onto a surface of a paper web a coating layer that is essentially skip free. Such an applicator is shown in Fig. 2 and is configured to cause air entrained in a coating liquid sheet that is emitted from an elongate fountain outlet nozzle, to move to a side of the sheet that is opposite from the side that is impinged against the web, so that only coating liquid that is relatively free of entrained air contacts the web surface. This is accomplished by flowing the coating liquid sheet along a curved surface of the applicator, to subject the coating liquid sheet to centrifugal force to cause the dense coating liquid to move toward a side of the coating liquid sheet that is toward the curved surface and impinged against the paper web, and air entrained in the coating liquid to move toward an opposite side of the sheet that is away from the curved surface and out of substantial contact with the web. The radius of the curved surface is selected for the magnitude of centrifugal force desired, the magnitude also being a function of the flow velocity of the coating liquid sheet across the curved surface. The flow velocity of the coating liquid sheet is, in turn, a function of the cross sectional area of the fountain outlet nozzle and of the volume flow rate of coating liquid through the nozzle, and must be such as to ensure that the coating liquid applied onto the paper web completely and uniformly covers the web surface.

More particularly, the fountain applicator of Fig. 2 is indicated generally at 50 and applies onto a surface of a paper web 52, which is carried past the applicator on a backing roll 54 that rotates in a direction as shown by an arrow 56, an excess layer of coating liquid that is doctored to a desired coat weight by a downstream doctor means such as a blade 58. The fountain applicator is part of a paper coating machine, and extends in the cross-machine direction, parallel to the backing roll 54 and transversely of, across and spaced from the backing roll supported web. The applicator has front and rear walls 60 and 62, and attached to the upper end of the rear wall is a plate 64. The front and rear walls and the plate form a chamber 66 therewithin, into which liquid coating material is delivered under pressure via a coating liquid distribution pipe 68 that extends longitudinally through the chamber and has a plurality of coating outlet openings 69 longitudinally spaced therealong. The front and rear walls may be hinged at their lower ends for movement apart to provide access to the chamber 66 for cleaning, for example as taught by U.S. patent No. 4,534,309.

A metering slot 70 is defined between the front wall 60 and the plate 64. The metering slot extends upwardly from the chamber 66 and transversely of and across the backing roll supported web 52, and from bottom to top is inclined toward the front of the applicator to enhance a migration of air entrained in the coating liquid toward the side of the metering slot defined by the plate. A replaceable elongate deflector tip 72 is at the upper end of the front wall and an elongate outlet nozzle 74 from the metering slot is at the top of the plate 64 between the plate and the deflector tip. On its side toward the outlet nozzle, the deflector tip has an elongate flat surface 76 and an elongate concave curved surface 78 that is positioned proximate to, transversely of and spaced from the web. The flat surface begins within the metering slot, it may but does not

necessarily need to extend upwardly beyond the outlet nozzle, and leads to the curved surface. Coating liquid exiting the elongate outlet nozzle flows in a sheet along the flat surface of the deflector tip to, along and then off of the curved surface in a free standing jet curtain of coating liquid that is directed against and across the web surface at an appropriate included acute angle. If desired, the downstream end of the coating liquid flow surface of the deflector tip could terminate in an elongate flat surface (not shown) of relatively limited length beyond the curved surface 78, along which the coating liquid sheet would flow after leaving the curved surface and before being projected toward the web in a free standing jet curtain of coating liquid. Also, adjustable deckle devices (not shown) may be at opposite ends of the elongate outlet nozzle to control its transverse extent and, therefore, the transverse extent of the sheet of coating liquid, thereby to control the width of the coating layer applied onto the web.

Before considering the manner of operation of the fountain applicator 50, a typical coating supply system for the applicator will first be considered in general terms. As seen in Fig. 3, a coating supply system may include a covered surge tank 82 for holding a main supply of liquid coating material that is stirred by a motor driven impeller unit 84. Coating liquid flows from the tank through a valve 86 to a pump 88 that delivers the coating liquid under pressure through a valve 90 and a mesh filter 92 to an air removal device 94. The air removal device may be of a conventional type, and operates to remove entrained air from coating liquid supplied from the surge tank and to deliver the removed air, carried in a small portion of the coating liquid, through a valve 96 for return to the surge tank. The remaining coating liquid exiting the air removal device is flowed through a valve 98 into one end of the distribution pipe 68 of the fountain applicator 50. At an

opposite end of the distribution pipe there is an outlet 100 from the top of the distribution pipe (Fig. 2), that leads back to the surge tank through a valve 102. The outlet allows recirculation of a small portion of the coating liquid supplied to the distribution pipe, in order to remove accumulated air from the top of the distribution pipe and enhance a uniform pressure of coating liquid throughout the chamber 66 for uniform application of coating onto the moving web. Valves 104 and 106 selectively direct coating liquid returned from the fountain applicator to the surge tank, to a sewer and/or to reclamation apparatus. A valve 108 is connected between the upstream side of the valve 90 and the surge tank, and a valve 110 at an outlet from the surge tank leads to the sewer or the reclamation apparatus. When the fountain applicator is operating, the valves 86, 90, 96, 98, 102 and 104 are open and the valves 106, 108 and 110 are closed. When the fountain applicator is not operating, the various valves are selectively opened or closed to accomplish a desired result (e.g., to accomodate cleaning of the system with wash water), as is readily understood by those skilled in the art.

In operation of the fountain applicator 50 and with reference to Fig. 2, coating liquid delivered to the applicator by the coating supply system is introduced into one end of the distribution pipe 68 and flows through the pipe openings 69 into the chamber 66. The air removal device 94 removes from the coating liquid much of the entrained air, but it is not 100 % effective, so some air remains entrained in the coating liquid delivered to the applicator. Some of the remaining air that accumulates at the top of the distribution pipe passes through the outlet 100 and is removed, but some still remains entrained in the coating, and with prior fountain applicators this limited amount of remaining entrained air causes skip coating on a paper web. However, in use of the applicator of the

invention, entrained air remaining in the coating liquid flowed from the chamber 66 and out of the outlet nozzle 74 is prevented from contacting the surface of the web, and therefore from causing skip coating.

More specifically, coating liquid delivered into the chamber 66 flows upwardly through the metering slot 70 and exits the elongate outlet nozzle 74 in an elongate sheet 112 of coating liquid that extends transversely of the paper web 52. The sheet of coating liquid flows along the deflector tip flat surface 76 to the concave curved surface 78, where the sheet is forcefully flowed against the curved surface as its direction of flow changes to conform to the curved surface. Causing the coating liquid sheet to follow the curved surface subjects it to centrifugal force that causes the dense coating liquid to move toward a side 116 of the sheet that is toward the curved surface and the much less dense air entrained in the coating liquid to move toward an opposite side 118 of the sheet that is away from the curved surface. After flowing along the curved surface, the sheet of coating liquid is projected from the deflector tip in a free standing elongate jet curtain of coating liquid that is directed toward, transversely across and against the paper web surface, such that an included acute angle β is defined between the plane of the jet curtain of coating liquid and a tangent to the web at the point of contact of the curtain with the web. In consequence, only the side of the jet curtain of coating liquid that corresponds to the side 116 of the coating liquid sheet that is relatively free of entrained air, is impinged against the surface of the web, while the side of the jet curtain of coating liquid that corresponds to the opposite side 118 of the sheet, to which most of the entrained air has moved, is out of substantial contact with the web, so that a skip-free coating is applied onto the web. The layer of coating liquid applied onto the web by the applicator is

in excess and is doctored to a desired coat weight by the downstream doctor means 58.

The minimum centrifugal force to which the sheet of coating liquid 112 is to be subjected is that which just results in application of a substantially skip-free coating onto the paper web 52. As is known, the centrifugal force exerted on the sheet of coating liquid is equal to the product of the mass of the coating liquid and its flow velocity squared, divided by the radius of the deflector tip curved surface 78. The mass of the coating liquid may be considered as a constant, which in practical terms means that the centrifugal force may be varied by changing either the flow velocity of the coating liquid sheet or the radius of the curved surface. The flow velocity of the coating liquid sheet is a function of the cross sectional area of the elongate outlet nozzle 74 and of the volume flow rate of coating liquid through it, and is chosen so that the applied coating completely and uniformly covers the web surface. Since there are limits on the minimum volume flow rate of coating liquid required to obtain a uniform coating on the paper web, and since there are practical limits on the maximum volume flow rate of coating liquid that can be forced throught the metering slot 70 and outlet nozzle 74, to subject the coating liquid stream to a desired centrifugal force, it usually is most convenient to control the radius of the deflector tip curved surface 78.

Nevertheless, while the magnitude of centrifugal force exerted on the coating liquid sheet may be increased by decreasing the radius of the deflector tip curved surface, there also are practical limits on how small the radius may be. It presently is contemplated that the curved surface have a radius on the of about .125" to .500", which is believed to be sufficient to properly densify the coating liquid on the side 116 of the coating liquid sheet that is impinged against the web or, put another way, to cause a

sufficient amount of the entrained air to move to the side 118 of the sheet that is out of substantial contact with the web, so that skip coating does not result. It also is contemplated that the curved surface have an arcuate extent in the range of about 45° to 90°, with about 70° likely being optimum.

The angle of attack of the free standing jet curtain of coating liquid against the paper web, i.e. the included angle between the plane of the curtain of coating liquid and a tangent to the web surface at the point of contact of the curtain with the web, should be chosen to obtain optimum coating results. For the applicator 50, good coating results have been experimentally obtained with an included angle of 50° when using an outlet nozzle 74 having a width of .048", with the linear distance between the upper end of the deflector tip curved surface 78 and the point of impact of the coating liquid curtain against the web being on the order of .312", and with the deflector tip flat surface 76 having a length of about .125" in the direction of flow of the coating liquid sheet. However, these particular parameters may have other values, since the optimum value of each parameter is influenced by and generally dependent upon the values of the other parameters, and it is contemplated that the outlet nozzle have a width in the range of about .025" to .050" and also that the flat surface 76 on the deflector tip could eliminated, in which case the curved surface 78 would begin immediately at the outlet nozzle 74.

While in the fountain applicator 50 shown in Fig. 2, the coating liquid flow surfaces 76 and 78 of the deflector tip 72 are exposed to the outside of the applicator and located downstream from the metering slot 70 and the elongate outlet nozzle 74, the fluid flow surfaces could be part of and located within the fluid flow path defined by the metering slot 70. In this case, as shown in Fig. 4, the

upper end of the plate 64 is extended along, spaced from and curved to conform to the fluid flow surfaces 76 and 78, so that the metering slot then extends along and includes the fluid flow surfaces. With this arrangement the coating liquid sheet is subjected to centrifugal force while within the upper end of the metering slot, an elongate outlet nozzle 74' is at the uppermost end of the deflector tip, and the free standing jet curtain of coating liquid is emitted directly from the elongate outlet nozzle.

To collect run-off coating liquid that is not carried away on the paper web 52, a run-off deflector 120 is on the outer surface of a chilled water jacket 122 carried on the plate 64. The run-off deflector leads to a return pan, from which coating liquids is returned to the surge tank 82, and the chilled water jacket facilitates cleaning of the run-off deflector.

Figs. 5A and 5B show coating results obtained experimentally when coatings were applied onto the same grade of paper with a fountain applicator constructed according to Fig. 2 and operated according to the teachings of the invention. Fig. 5A shows 75° gloss obtained at various web speeds and Fig. 5B shows Parker Printsurf smoothness measurements obtained at various web speeds.

While one embodiment of the invention has been described in detail, various modifications and other embodiments thereof may be devised by one skilled in the art without departing from the spirit and scope of the invention, as defined in the appended claims.

What Is Claimed Is:

1. In an apparatus for applying a coating liquid onto a surface of a moving web, comprising:
a body having a chamber therein, an elongate outlet nozzle from said chamber positioned transversely of the web, and an elongate coating liquid deflector that is positioned proximate to, spaced from and transversely of the web and that has an elongate concave curved surface; and
means for pressure delivery of coating liquid onto said chamber for flow through said elongate outlet nozzle and along said elongate deflector curved surface in an elongate sheet of coating liquid that, after flowing along said curved surface, is projected in a free standing elongate jet curtain of coating liquid toward, across and against the surface of the web,
the coating liquid sheet, while flowing along said deflector curved surface, being subjected to centrifugal force that causes the coating liquid to move toward one side of the coating liquid sheet that is toward said curved surface and air entrained in the coating liquid to move toward the opposite side of the coating liquid sheet, and said deflector being oriented relative to the web so that one side of the jet curtain of coating liquid that corresponds to the one side of the coating liquid sheet is impinged against the surface of the web while the opposite side of the jet curtain of coating liquid that corresponds to the opposite side of the coating liquid sheet is out of substantial contact with the surface of the web, whereby the coating liquid contacting the web surface is relatively free of entrained air to provide on the web surface a coating that is substantially skip free.

2. In an apparatus as in claim 1, wherein said deflector curved surface has an arcuate extent in the range of about 45° to 90°.

3. In an apparatus as in claim 1, wherein said deflector curved surface has a radius in the range of about .125" to .500".

4. In an apparatus as in claim 1, wherein said elongate outlet nozzle has a width in the range of about .025" to .050".

5. In an apparatus as in claim 1, wherein the included angle between the plane of the free standing jet curtain of coating liquid and the surface of the web at the point of contact of the jet curtain of coating liquid with the web is in the range of about 30° to 50°.

6. In an apparatus for applying a coating liquid onto a surface of a moving web, comprising:
a coating liquid flow path that is laterally elongate and that includes a laterally elongate concave curved surface, a downstream end of said flow path being positioned proximate to, spaced from and transversely of the web; and
means for flowing coating liquid along said flow path and beyond said downstream end of said flow path in a free standing laterally elongate jet curtain of coating liquid that is directed toward, across and against the surface of the web,
the coating liquid, while flowing along said flow path curved surface, being subjected to centrifugal force that causes air entrained in the coating liquid to move away from said curved surface, the free standing jet curtain of coating liquid being directed against the web to impinge a side of the jet curtain of

coating liquid, which consists substantially of coating liquid that was toward said curved surface, against the web surface while the other side of the jet curtain of coating liquid is out of substantial contact with the web surface, whereby only coating liquid that is relatively free of entrained air contacts the web surface to provide on the web surface a coating that is substantially skip free.

7. In an apparatus as in claim 6, wherein said curved surface has an arcuate extent in the range of about 45° to 90°.

8. In an apparatus as in claim 6, wherein said curved surface has a radius in the range of about .125 inch to .500 inch.

9. In an apparatus as in claim 6, wherein the included angle between the plane of the free standing jet curtain of coating liquid and the surface of the web at the point of contact of the free standing jet curtain of coating liquid with the web is in the range of about 30° to 50°.

10. In an apparatus as in claim 6, wherein said concave curved surface is proximate to said downstream end of said flow path.

11. In an apparatus as in claim 6, wherein a downstream end of said concave curved surface is at said flow path downstream end.

12. In an apparatus as in claim 6, wherein said means for flowing includes an elongate outlet nozzle positioned along and laterally of said flow path and means for pressure delivery of coating liquid to said outlet nozzle for flow through said outlet nozzle to and

along said flow path concave curved surface in an elongate sheet of coating liquid.

13. In an apparatus as in claim 12, wherein said elongate outlet nozzle has a width in the range of about .025" to .050".

14. A method of applying a coating liquid onto a surface of a moving web, comprising:
flowing coating liquid along an elongate concave curved surface that is positioned proximate to, spaced from and transversely of the web to subject the coating liquid to centrifugal force that causes air entrained in the coating liquid to move away from the curved surface; and
directing the coating liquid, after it has flowed along the curved surface, in a free standing elongate jet curtain of coating liquid toward, across and against the surface of the web to contact the web surface with a side of the jet curtain of coating liquid that consists substantially of coating liquid that was toward the curved surface while maintaining the other side of the jet curtain of coating liquid out of substantial contact with the web surface, whereby only coating liquid that is relatively free of entrained air contacts the web surface.

15. A method as in claim 14, wherein the curved surface has an arcuate extent in the range of about 45° to 90°.

16. A method as in claim 14, wherein the curved surface has a radius in the range of about .125 inch to .500 inch.

17. A method as in claim 14, wherein said step of directing the coating liquid sheet is performed sucht

that the included angle between the plane of the free standing jet curtain of coating liquid and the surface of the web at the point of contact of the jet curtain of coating liquid with the web is in the range of about 30° to 50°.

18. A method as in claim 14, wherein said flowing step comprises delivering coating liquid under pressure to an elongate nozzle, emitting the coating liquid from the nozzle in an elongate sheet of coating liquid, and flowing the elongate sheet of coating liquid along the elongate curved surface to subject the coating liquid sheet to centrifugal force.

19. A method as in claim 18, wherein the elongate nozzle has a width in the range of about .025" to .050".

20. A method of applying coating liquid onto a surface of a moving web, comprising:
forming a sheet of coating liquid;
subjecting the sheet of coating liquid to centrifugal force to cause air entrained in the coating liquid to move toward one side of the sheet, so that an opposite side of the coating liquid sheet is then relatively free of entrained air;
projecting the sheet of coating liquid toward the web in a free standing sheet of coating liquid; and
contacting the surface of the web with the opposite side of the coating liquid sheet that is relatively free of entrained air while maintaining the one side of the coating liquid sheet out of substantial contact with the web surface.

21. A method as in claim 20, wherein said subjecting step comprises flowing the sheet of coating liquid across a concave curved surface.

22. A method of applying coating liquid onto a surface of a moving web, comprising:
flowing coating liquid across a concave curved surface at a flow velocity that is sufficient, when taken together with the curvature of the curved surface, to subject the coating liquid to centrifugal force of a magnitude that causes a substantial portion of air entrained in the coating liquid to move to a side of the coating liquid that is away from the curved surface;
after said flowing step, directing the coating liquid toward the web surface in a free standing jet curtain of coating liquid; and
impinging one side of the jet curtain of coating liquid, that corresponds to an opposite side of the coating liquid that was toward the curved surface, against the surface of the web while maintaining the other side of the jet curtain of coating liquid out of substantial contact with the web surface, whereby only coating liquid that is relatively free of entrained air contacts the web surface.

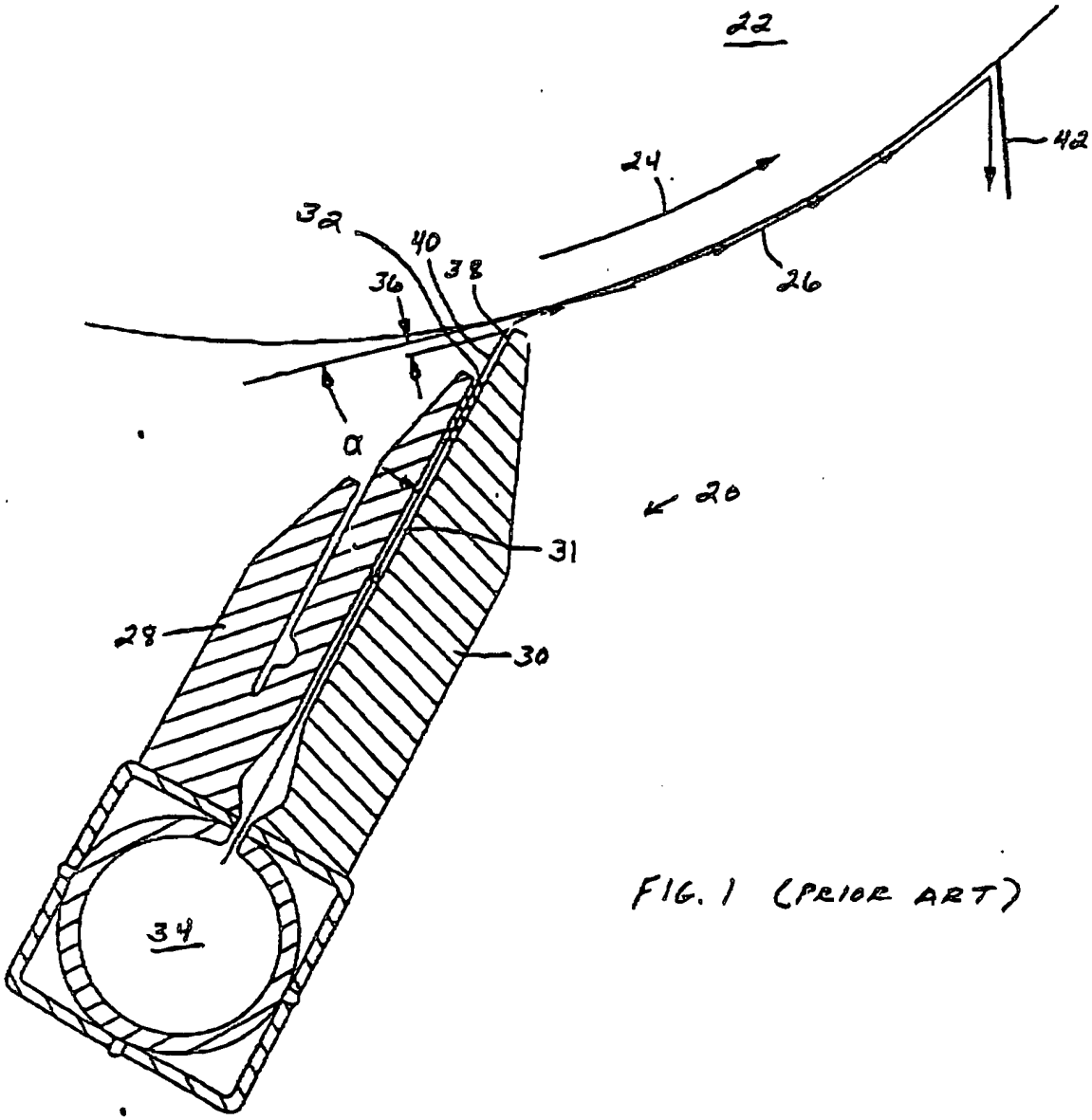

FIG. 1 (PRIOR ART)

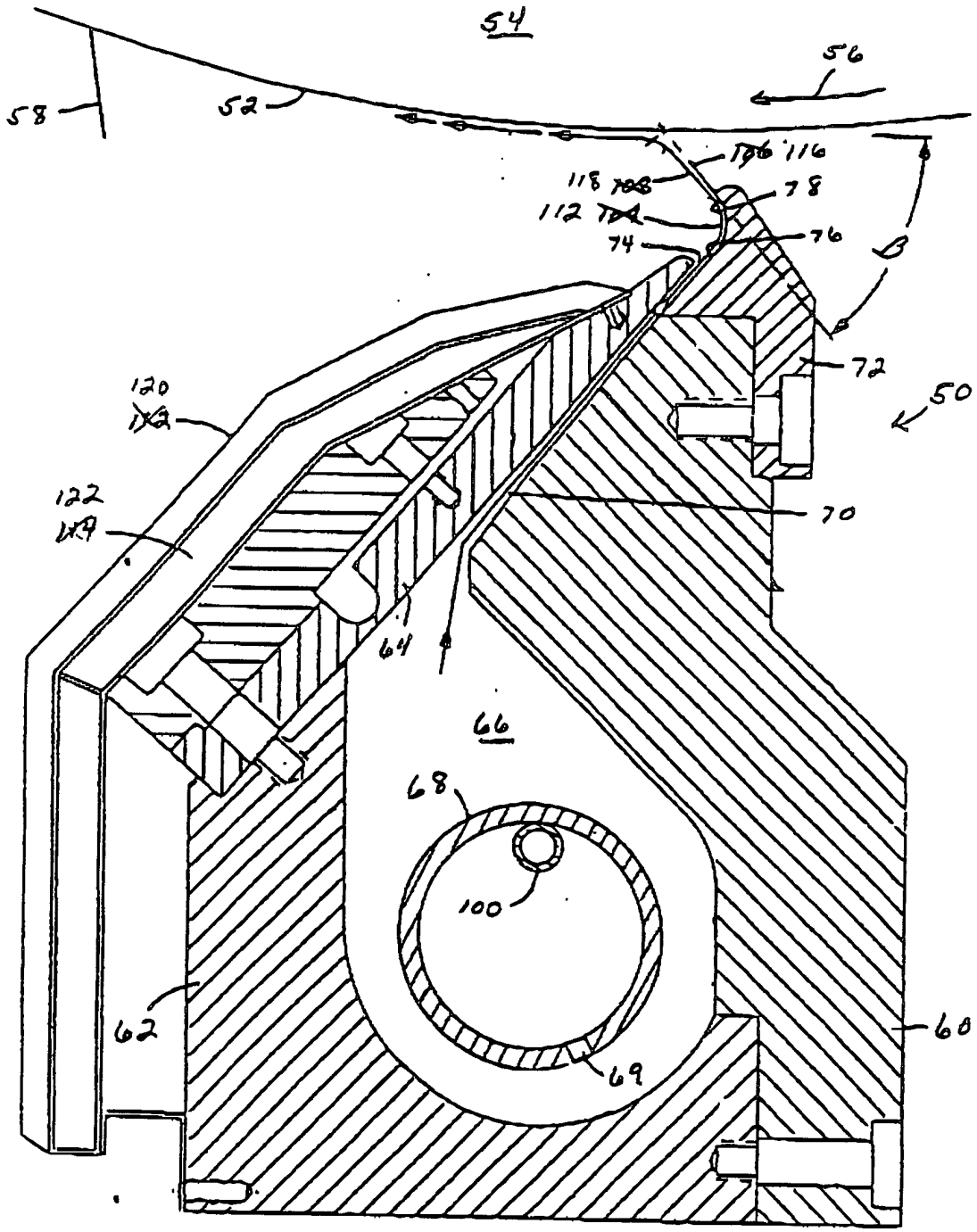
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FIG. 2

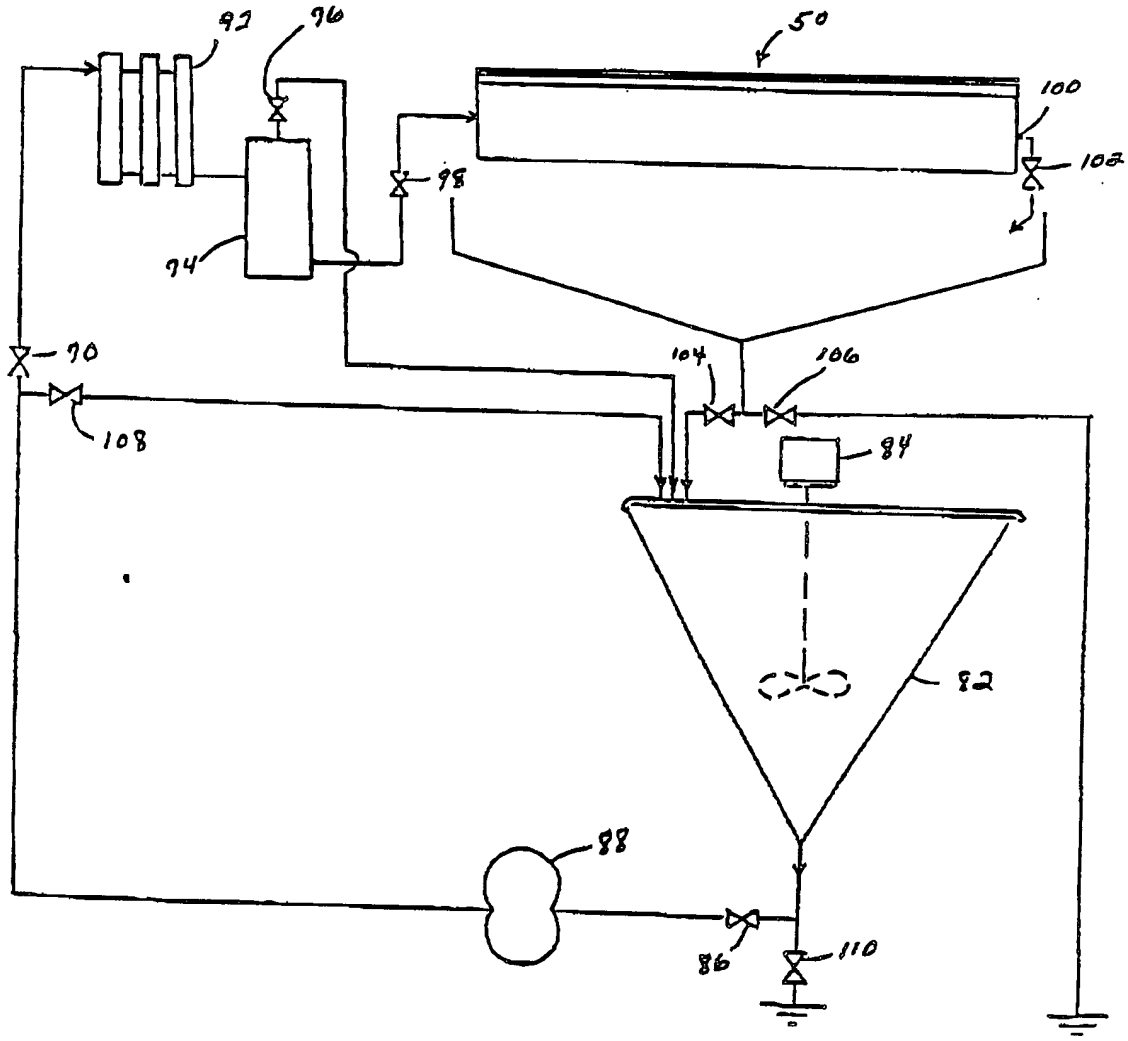
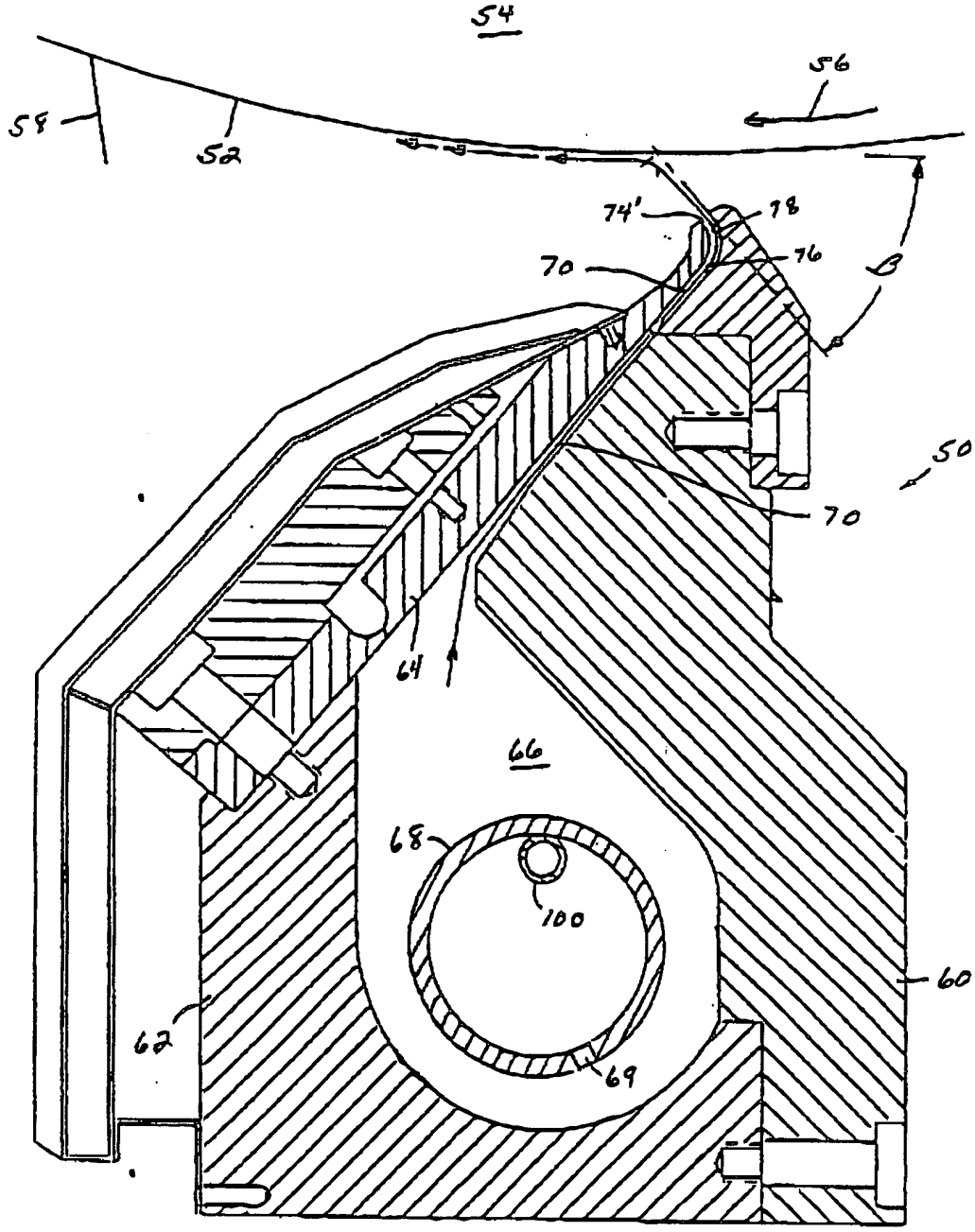


FIG. 3



SUBSTITUTE SHEET (RULE 26) FIG. 4

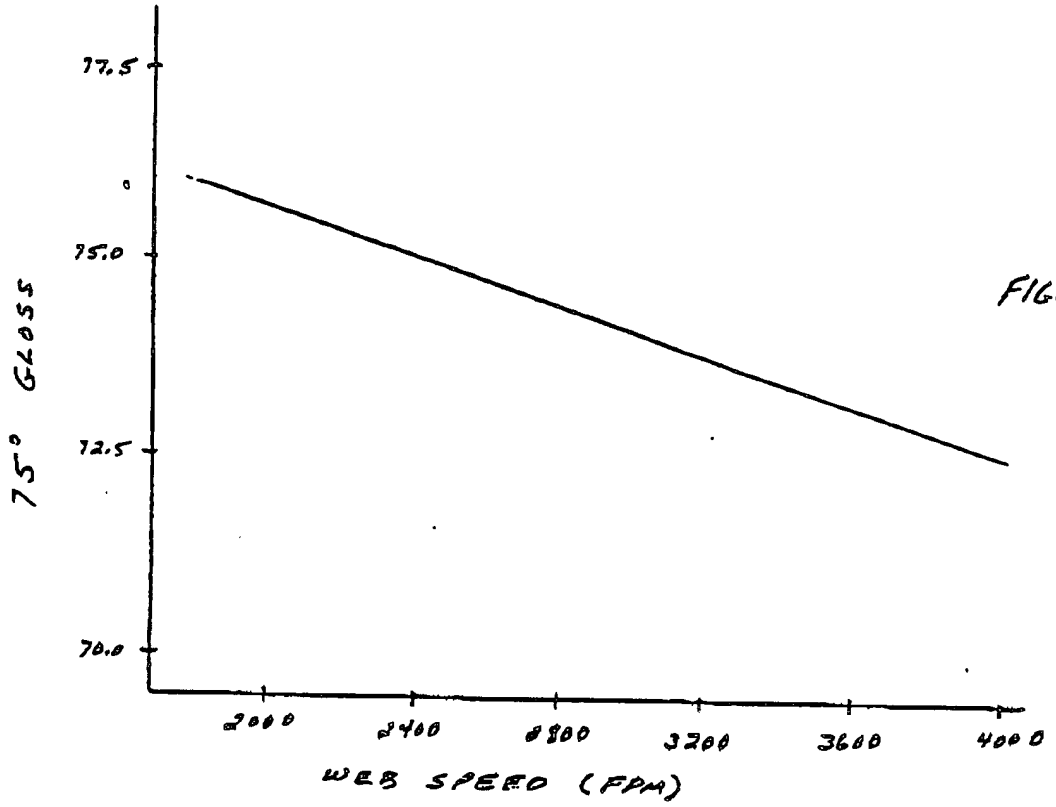

77.5
75.0
72.5
70.0
75° GLOSS
2000
2400
2800
3200
3600
4000
WEB SPEED (FPM)

FIG. 6A

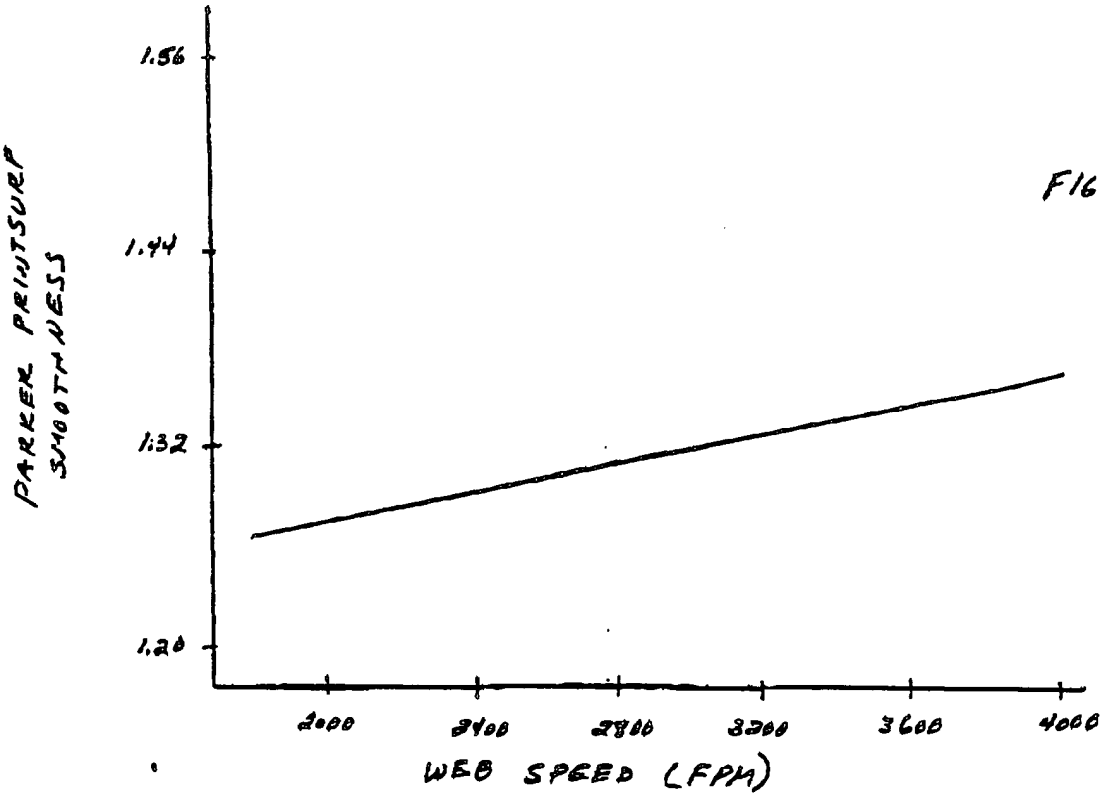

1.56
1.44
1.32
1.20
PARKER PRINTSURF SMOOTHNESS
2000
2400
2800
3200
3600
4000
WEB SPEED (FPM)

FIG. 5B

INTERNATIONAL SEARCH REPORT

Intern. al Application No
PCT/EP 93/02452

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 D21H23/32

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 D21H B05C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
E	CA,A,2 101 358 (CONSOLIDATED PAPERS, INC.) 12 March 1994 see the whole document	1-22
A	US,A,4 534 309 (DAMRAU ET AL.) 13 August 1985 cited in the application see the whole document	1-22

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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INTERNATIONAL SEARCH REPORT

Intern J Application No
PCT/EP 93/02452

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
CA-A-2101358	12-03-94	NONE	
US-A-4534309	13-08-85	NONE	

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